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RECEIVED MAY 0 1 1991

Accurate Three-Dimensional Calculations for Advancing Slip Zones in the Earth's Crust

(Joint funding with NSF Grant EAR-8707392)

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(For period October 1, 1990 to March 31, 1991)

Objectives

Understanding the mechanism by which slip is transmitted from depth to the surface and along the strike of the fault from freely slipping to locked zones is of great importance for understanding the earthquake process and for possibly anticipating damaging events. A major impediment to more accurate and realistic analyses has been the difficulty of making calculations for three dimensional cracked bodies. We are doing three-dimensional analysis of slip zones (cracks) in an elastic half-space to determine stresses and surface deformations due to the advance of shear faults into locked, or more resistant, portions of the shallow crust. The goal of these studies is to understand three-dimensional geometric effects on the intensity of stressing near the edges of slip zones.

Results

Work during the current period has focussed on the development and implementation of an analytical solution for constant slip in a triangular region in an elastic half-space. The solution is constructed by superposition using Comninou's [1973] solution for an angular dislocation in a half-space. Because triangular elements can be used to model arbitrarily-shaped slip zones, this solution has advantages over solutions for uniform slip in rectangular elements. For a vertical rectangular fault, the solution has been checked against that of Chinnery [1961] by combining two triangular elements to make a rectangle. For dipping faults, the solution has been checked against numerical results for a rectangular fault provided by Simpson [personal communication, 1990].

When uniform slip triangles are combined to approximate a slip zone of uniform stress drop (by solving for the slip in each triangle needed to yield a given value of the stress drop at the centroid of the triangle), the results indicate that they overestimate the free surface displacements by comparison with the more elaborate calculations of Wu et al. [1991]. This occurs because the uniform slip elements do not allow the fault surface relative slip to taper smoothly to zero at the edges of the slip zone, as does the procedure of Wu et al. [1991]. Nevertheless, the discrepancy diminishes with increasing number of elements and calculations using the uniform slip triangles are substantially more efficient.

Examination of the stress predicted near the edge of a slip zone made up of uniform slip triangles indicates that, as expected, the stress is more singular than the $r^{-1/2}$ behavior near a crack in an elastic body. Unfortunately, we have, as yet, found no reliable method for inferring the stress intensity factors (and energy release rates) from results for the uniform slip triangles.

References

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